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## CANNIBALIZATION STUDY FOR PACIFIC AIR FORCES

AFLMA Report (LM 200200402)

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## AIR FORCE LOGISTICS MANAGEMENT AGENCY

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14. ABSTRACT In early 2002, the Headquarters Pacific Air Forces Director of Logistics (PACAF/LG) requested that the AFLMA conduct a study of PACAF cannibalizations (CANN). In particular, he requested the Agency focus on determining the feasibility of establishing Air Force standards for cannibalizations, and to evaluate the Readiness Spares Package (RSP) review process for assigning particular items as cannibalization candidates. Although this report was conducted at the request of the PACAF/LG and uses PACAF cannibalization data for analysis, its results are relevant to the entire Air Force. To accomplish the tasking, the AFLMA studied data from AF maintenance and supply data systems and conducted interviews with MAJCOM and wing personnel in PACAF. The study indicates an AF standard for CANNs is feasible, but shows that an additional metric is needed to get a more holistic view of the CANN impact. A new metric was developed to highlight the impact of CANN activity on maintenance personnel resources. It was also determined that the assignment of RSP items as CANN candidates could be improved by using ranked historical CANN data during the annual RSP process.					
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## *Executive Summary*

### **Problem Statement**

**Cannibalization (CANN)** is defined as the authorized removal of a specific assembly, subassembly, or part from one weapon system, support system, or equipment end-item for installation on another end-item to meet priority mission requirements with an obligation to replace the removed item.<sup>1</sup> Generally, the process starts with a not mission capable (NMC) system requiring a replacement part. When the part cannot be issued from supply within the required timeframe, it is removed from a donor system that is usually also NMC. Once the CANN is complete, one of the two systems becomes mission capable (MC).

It is current Air Force practice to measure CANN activity by the number of times a CANN event occurs, alternatively said, the number of supply chain failures. The Air Force has not established "standards" by which CANN activity is evaluated for each aircraft mission design series (MDS). The Air Force continues to expend a significant number of maintenance man-hours on CANN actions; however, the impact of expending these man-hours is not measured. Finally, automated tools do support the Readiness Spares Package (RSP)<sup>2</sup> authorization computation process. However, the process for determining whether the RSP computation model considers an item as a feasible or nonfeasible CANN when it computes authorized quantities is largely subjective and is not assisted by models or automated in any manner.

### **Background**

Citing a post-Cold War decline in inventory requirements based on force structure reductions, Department of Defense (DoD) guidance in early 1991 directed that spares purchasing and inventory be drastically reduced.<sup>3</sup> At the same time, the United States Air Force began supporting a much greater number of worldwide contingencies while adopting new logistics support concepts. This led to difficulties in spares requirements forecasting. In the early 1990s, the Air Force also started a personnel drawdown that led to a significant loss of experienced aircraft maintainers. Furthermore, the average age of the Air Force fleet increased to over 22 years. Some weapon systems are experiencing the pain of obsolescence with a diminishing manufacturer base for their spares and repair

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<sup>1</sup> Air Force Instruction 21-101, *Aerospace Equipment Maintenance Management*, 1 February 2002

<sup>2</sup> A Readiness Spares Package is a package of spares, repair parts, and related maintenance supplies required to sustain a weapon system for a specified period of planned wartime or contingency operations. There are two major types of RSP, mobility and in-place. The mobility RSP is stand-alone support for a deployed unit. The in-place RSP is designed to support units that conduct wartime operations from their home base and includes only the parts needed over and above the normal peacetime operating supply stock.

<sup>3</sup> Defense Management Report Decision No. 987, *Inventory Reduction Plan Improvements*, January 7, 1991.

support. These factors contributed to an environment that generated sustained, high CANN numbers throughout the decade.

The practice of cannibalizing parts has been used throughout Air Force history as a maintenance strategy to compensate for supply chain failures. The negative aspect of CANNs is increased labor cost. Maintenance actions must be accomplished twice, first to remove the donor part and install it on the receiving aircraft, then reinstall a part when available to fill the hole left in the donor aircraft. Recent General Accounting Office (GAO) reports and AF data suggest that CANN actions are extensively utilized to maintain aircraft availability in particular weapon systems.

To address the issue of getting more spares to the field, thereby reducing the number of CANN events, several Air Force initiatives have been implemented. Some of these efforts include increased funding for requirements, the Spares Campaign, and the Depot Maintenance Reengineering and Transformation (DRMT). In addition, the Air Force Director of Maintenance (USAF/ILM) has initiated the Keep Enlisted Experience Program (KEEP) in an effort to promote the retention of experienced enlisted maintenance personnel. At the wing-level, commanders have sought organizational solutions, such as consolidated CANN aircraft management, to address high CANN activity. While these efforts should have a positive effect on reducing the number of CANNs, they will not be able to eliminate CANN events. Even as aggregate Air Force statistics may indicate that CANN rates are falling, there will still be MDSs that experience high CANN rates.

Major commands (MAJCOM) conduct RSP reviews annually in association with Air Force Materiel Command (AFMC). The purpose of the review is to update the range of items in authorized RSPs and to verify the complete set of data used to compute quantities (depth) for the range of items. Part of the data verification is the assignment of CANN candidate flags for each item. Once assigned, the CANN candidate flag indicates to the RSP authorization model whether the item is a feasible or nonfeasible CANN. If the flag is set to *feasible*, the model will compute the authorization for that item assuming that it could be cannibalized from a donor aircraft. Thus, in many instances the authorized RSP quantity of an item that is a *feasible CANN* will be computed to zero. When the flag is set to *nonfeasible*, the authorization will automatically be computed to the minimum pipeline quantity. Maintenance subject matter experts currently make CANN flag assignments based upon their experience and without support from mathematical models.

## Objective

This study has two objectives. The first is to determine the feasibility of establishing Air Force standards for CANN rates. The second is to review the current RSP CANN candidate process and evaluate the necessity for interjecting historical data or a mathematical model.

## Assumptions and Constraints

It is commonly believed that CANN events are underreported in the Core Automated Maintenance System (CAMS). Comparisons of manual CANN logs and CAMS data show that not every CANN event is recorded in CAMS. CANN man-hours are also underreported. CAMS requires the user to input only the start time of the uninstall action (T) and the time the reinstall action (U) is complete. The result is some man-hours associated with a CANN event (pre-inspections, towing and operations checks) are not recorded with the CANN. Thus, the actual number of CANN events may be higher than recorded and man-hours expended for the CANN events are higher than actually recorded. However, the only automated collection source for CANN data is CAMS. We assume the fidelity of the data available in CAMS is sufficient for analysis and recommendations. The authors also acknowledge that a different system, CAMS for Mobility, or GO81, is used for maintenance data collection on Air Mobility Command (AMC)-owned and gained aircraft. In this study we did not look specifically at AMC aircraft; thus, we did not pull data from, perform analysis, or make recommendations specifically for GO81.

The first objective was to determine the feasibility of establishing Air Force CANN standards. In the project sponsor's request, we were asked to look at standards for CANNs resulting from both supply chain failure and maintenance convenience. At the present time, there is no widely accepted definition of a *maintenance convenience* CANN. Even with an established definition, there is no capability within CAMS to record a cause for a CANN event. Thus, data is collected without distinguishing between supply chain failure and maintenance convenience CANNs. This report makes recommendations for CANN rates regardless of cannibalization causal factors.

## Analysis

The increase in aircraft availability goals<sup>4</sup> used in supply sustainment models—Aircraft Availability Targets (AAT) for peacetime operating stock and Desired Stockage Objectives (DSO) for RSPs, increased Air Force and Defense Logistics Agency (DLA) funding of aviation parts, and Air Force stockage policy changes should have an immediate effect in execution years in reducing CANN events. Since the increased funding began FY99, supply backorders have been reduced from 615,529 in December 1998 down to 191,823 in April 2002. In the out years, process improvements and policy changes realized from the Spares Campaign and DRMT will result in better spares acquisition and management, thus providing an environment for continued CANN reduction. AF/ILM is actively seeking solutions to improve the retention rates of 5- and 7-level maintenance technicians. Although we can not prove that CANN reductions will occur as retention rates improve, it is intuitive that the impact of the maintenance workload from CANNs will be more equitably shared when the 5- and 7-level personnel requirements are more closely met.

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<sup>4</sup> Aircraft availability goals are determined by Air Staff. They represent the target aircraft availability that a model should strive for while computing supply-authorized levels. An increase in aircraft availability goals would mean a subsequent increase in range and depth of supply items.

Deciding how and where to set an Air Force standard for CANNs is feasible. To set an Air Force standard, the right metrics must be targeted. The formula the Air Force uses today to calculate a CANN rate (CANNs per 100 sorties) does measure the level of CANN activity. It is an indicator of how many supply chain failures have occurred for a particular weapon system; thus, it is indicator of supply support to the warfighter. However, the current formula does not reflect the cost or *pain* of doing CANNs. One way to do this is to measure CANN man-hours as a percentage of total maintenance man-hours expended, a CANN workload rate. If it is determined that the Air Force needs to track CANNs against established standards, then *both* metrics should be evaluated. In this study, the two metrics are identified as cannibalization rate for supply or CANN (S) and cannibalization rate for maintenance workload or CANN (M).

The CANN (M) rate has sub-elements that can be analyzed. By identifying the 5-digit work unit codes (WUC) that are driving the CANN workload, corrective supply and maintenance actions can be taken. For example, a supply manager at base level could assess the stockage and issue effectiveness of the part-numbered items associated with the 5-digit WUC, as well as assess the depot stockage and repair capacities. Maintenance managers could evaluate on-base repair capabilities for bottlenecks. At the MAJCOM level, this information could be useful to negotiate increased spares levels in peacetime operating stock (POS) and RSPs.

Another sub-element under the CANN (M) rate is the data that reflects which maintainers are shouldering the CANN burden. By identifying the Air Force specialty codes (AFSC) stressed by CANN man-hours, maintenance leadership can target organizational and personnel corrective actions.

The analysis of the RSP review process revealed mathematical models are involved in the spares computation. The Aircraft Sustainability Model (ASM) provides the authorized RSP quantities of items (depth), while the bases and MAJCOMs provide recommendations on which items (range of stock) their RSPs should include. However, when the CANN candidate flags are assigned, indicating whether or not an item can feasibly be cannibalized, the process is not automated or modeled in any fashion. The CANN flag assignment is based on the subject matter expertise of those maintainers consulted for the review. Research into CAMS and Standard Base Supply System (SBSS) revealed that relevant CANN and mission capable (MICAP) item data could be collected, ranked, and presented in a prototype assessment tool to assist in the CANN flag assignment. With F-15C/D CAMS and SBSS data from Kadena Air Base, Japan, and Elmendorf Air Force Base, Alaska, a product was built for the Pacific Air Forces (PACAF) Supply Directorate (LGS) to evaluate for Air Force-wide application during their next F-15C/D RSP review.

The collection of CANN data proved to be a laborious process because of the quality of data entered into CAMS. It is important to note that in our research it was abundantly clear that CANN data collection has not been made user-friendly for maintenance technicians. The result is that the technician will many times take the easiest route out of the documentation process, which often means dirty data into CAMS.



## Conclusions

Our research revealed that recent DLA and Air Force funding plus-ups have already begun to have a positive effect on CANN rates. The Air Force has also undertaken multiple process improvement initiatives to "get spares to the warfighter." These initiatives should further reduce CANN rates as processes for spares requirements forecasting, budgeting, and repair activities are improved. These efforts however, cannot completely eliminate CANN events, and some weapon systems will still experience high levels of CANN activity. Since CANNs result in an additional burden on maintenance resources, it is imperative that the Air Force establishes metrics to reflect the maintenance impact of CANN activity. If the Air Force opts to adopt standards for CANN rates, then the measure should reflect the CANN man-hours spent as a percentage of total maintenance man-hours expended by MDS or CANN (M), in addition to the current measure of CANN events per 100 sorties or CANN (S). Additionally, if Air Force standards are developed, further research into CANN policy and organization would be beneficial (e.g. CANN docks and hangar queen management).

Research into the current RSP review process found that various tools exist to support the MAJCOMs annual reviews. However, the assignment of CANN candidate flags for the computation model is still largely dependent on available subject matter expertise. Using an assessment tool comprised of historical CANN data available in CAMS and SBSS should improve the RSP review process by providing objective, decision-quality information for both maintenance and supply personnel. The result should be a more accurate and consistent process for the assignment of CANN candidate flags. However, the RSP assessment tool, or any CANN data analysis, is only as good as the data originally entered in CAMS. Although not formally part of the study objectives, it was apparent from the research that improvements are needed in CAMS (or identified for Integrated Maintenance Data System [IMDS]) to facilitate the maintainer's process for inputting CANN data. Additionally, since the CANN data is collected at the 5-digit WUC level, the product should be useful to personnel charged with manipulating the CANN data fed into the Logistics Composite Model (LCOM), which determines maintenance manpower requirements. Increasing the fidelity of the CANN data fed into LCOM should result in a more accurate modeling scenario, thus more accurate maintenance manpower requirements.

## Recommendations

1. USAF/ILM develop policy for reporting CANN rates with two metrics, CANN (S) CANN (M). MAJCOM/ LGs could supplement this policy, if required.
  - a) The CANN (M) rate, by MDS, be added as a metric for Air Staff-, MAJCOM-, and base level reporting of CANNs. The formula for its computation should be sent to all Analysis agencies.
  - b) The CANN (M) rate and the formula for its computation be added to the *U.S. Air Force Maintenance Metrics Handbook* at next publishing



- c) The CANN (M) rate be added into the Mission Performance cannibalization module of the Multi-Echelon Resources and Logistics Information Network (MERLIN) program to provide common access to this indicator.

**OPR: USAF/ILM**

**OCR: AFLMA (Item B)**

2. AF/ILM and MAJCOMs work together to determine the advisability of establishing AF standards for CANN rates. If the AF adopts CANN standards, then both CANN (S) and CANN (M) rates, by MDS, should be considered and the standards established by an integrated process team consisting of AF/ILM, MAJCOM/LGM, and AFLMA/LGM personnel.

**OPR: AF/ILM**

**OCR: MAJCOM/LGs, AFLMA**

3. CAMS (or the follow-on system) be modified for easier, more accurate collection and reporting of CANN data.
  - a. The three-screen process for entering CANN activity into CAMS should be streamlined.
  - b. Recommend CAMS be modified so a CANN history report can be run that captures WUC, national stock numbers (NSN), and nomenclature associated with each CANN event. REMIS should capture this data in order to roll up MAJCOM CANN histories by 5-digit WUC and NSN. The prototype assessment tool submitted with this report and validated by PACAF/LGS should be used as a template.

**OPR: USAF/ILM/ILG**

**OCR: SSG**

4. Once CANN history reports by WUC and NSN are available, recommend Air Force establish policy to incorporate them into the RSP review process. MAJCOMs should run reports prior to RSP reviews for their use in objectively assigning CANN candidate flags to RSP items.

**OPR: AF/ILM**

**OCR: MAJCOM/LGs, AFLMA**

5. Air Force review current criteria for assignment of CANN candidate flags. CANN flags should be assigned to the items with the highest CANN workload impact, the items that are cannibalized often and require an extensive amount of time to CANN. These are the items that rank highest in the prototype assessment tool.

**OPR: USAF/ILG**

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## Chapter 1

### Introduction

**Cannibalization (CANN)** is defined as the authorized removal of a specific assembly, subassembly, or part from one weapon system, support system, or equipment end-item for installation on another end-item to meet priority mission requirements with an obligation to replace the removed item.<sup>5</sup> Generally, the process starts with a not mission capable system requiring a replacement part. When the part cannot be issued from supply within the required timeframe, it is removed from a donor system that is usually also not mission capable. Once the CANN is complete, one of the two systems becomes mission capable.

In early 2002, the Headquarters Pacific Air Forces Director of Logistics (PACAF/LG) requested that the AFLMA conduct a study of PACAF cannibalizations. In particular, he requested the Agency focus on determining the feasibility of establishing Air Force standards for cannibalizations, and to evaluate the Readiness Spares Package (RSP) review process for assigning RSP items as cannibalization candidates.<sup>6</sup> Although this report was conducted at the request of the PACAF/LG and uses PACAF cannibalization data for analysis, its results are relevant to the entire Air Force. This report presents the results of our research and analysis conducted through the spring and summer of 2002.

### Background

Citing a post-Cold War decline in inventory requirements based on force structure reductions, Department of Defense (DoD) guidance in early 1991 directed that spares purchasing and inventory be drastically reduced.<sup>7</sup> At the same time, the United States Air Force began supporting a much greater number of worldwide contingencies while adopting new logistics support concepts. This led to difficulties in spares requirements forecasting. In the early 1990s, the Air Force also started a personnel drawdown that led to a significant loss of experienced aircraft maintainers. Furthermore, the average age of the Air Force fleet increased to over 22 years. Some weapon systems are experiencing the pain of obsolescence with a diminishing manufacturer base for their spares and repair support. These factors contributed to an environment that generated sustained, high CANN numbers throughout the decade.

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<sup>5</sup> Air Force Instruction 21-101, *Aerospace Equipment Maintenance Management*, 1 February 2002

<sup>6</sup> A Readiness Spares Package is a package of spares, repair parts, and related maintenance supplies required to sustain a weapon system for a specified period of planned wartime or contingency operations. There are two major types of RSP, mobility and in-place. The mobility RSP is stand-alone support for a deployed unit. The in-place RSP is designed to support units that conduct wartime operations from their home base and includes only the parts needed over and above the normal peacetime operating supply stock. RSP item authorizations are computed assuming that cannibalization will occur. Items in an RSP must be coded as a feasible or nonfeasible CANN prior to the computation runs.

<sup>7</sup> Defense Management Report Decision No. 987, *Inventory Reduction Plan Improvements*, January 7, 1991.

The practice of cannibalizing parts has been used throughout Air Force history as a maintenance strategy to compensate for supply chain failures. The negative aspect of CANNs is increased labor cost. Maintenance actions must be accomplished twice, first to remove the donor part and install it on the receiving aircraft, then reinstall a part when available to fill the hole left in the donor aircraft. Recent General Accounting Office (GAO) reports and AF data suggest that CANN actions are extensively utilized to maintain aircraft availability in particular weapon systems.

To address the issue of getting more spares to the field, thereby reducing the number of CANN events, several Air Force initiatives have been implemented. Some of these efforts include increased funding for requirements, the Spares Campaign, and the Depot Maintenance Reengineering and Transformation (DRMT). In addition, the Air Force Director of Maintenance (USAF/ILM) has initiated the Keep Enlisted Experience Program (KEEP) in an effort to promote the retention of experienced enlisted maintenance personnel. At the wing-level, commanders have sought organizational solutions to address high CANN activity. While these efforts should have a positive effect on reducing the number of CANNs, they will not be able to eliminate CANN events. Even as aggregate Air Force statistics may indicate that CANN rates are falling, there will still be MDSs that experience high CANN rates.

Major commands (MAJCOM) conduct RSP reviews annually in association with Air Force Materiel Command (AFMC). The purpose of the review is to update the range of items in authorized RSPs and to verify the complete set of data used to compute quantities (depth) for the range of items. Part of the data verification is the assignment of CANN candidate flags for each item. Once assigned, the CANN candidate flag indicates to the RSP authorization model that the item is a *feasible* or *non-feasible* CANN. If the flag is set to *feasible*, the model will compute the authorization for that item assuming that it could be cannibalized from a donor aircraft. Thus, in many instances the authorized RSP quantity will be computed to zero. When the flag is set to *non-feasible*, the authorization will automatically be computed to the minimum pipeline quantity. Maintenance subject matter experts currently make CANN flag assignments based upon their experience and without support from mathematical models.

## **Problem Statement**

It is current Air Force practice to measure CANN activity by the number of times a CANN event occurs, alternatively said, the number of supply chain failures. The Air Force has not established "standards" by which CANN activity is evaluated for each aircraft mission design series (MDS). The Air Force continues to expend a significant number of maintenance man-hours on CANN actions; however, the impact of expending these man-hours is not measured. Finally, automated tools do support the Readiness Spares Package (RSP) authorization computation process. However, the process for determining whether the RSP computation model considers an item as a feasible or non-feasible CANN when it computes authorized quantities is largely subjective and is not assisted by models or automated in any manner.

## Objectives

This study has two objectives. The first is to determine the feasibility of establishing Air Force standards for CANN rates. The second is to review the current RSP CANN candidate process and evaluate the necessity for interjecting historical data or a mathematical model.

## Scope

PACAF asked AFLMA to conduct a study of cannibalizations in PACAF for each aircraft MDS and each type/model/series (TMS) for engines. The project was narrowed to a case study of the F-15C/D in order to ensure it could be completed within a reasonable timeframe. The study request also highlighted the multi-layered aspect of the cannibalization issue. Several concerns were expressed, such as CANN reporting in the Core Automated Maintenance System (CAMS), the implications of CANN for the direct support objective (DSO) for RSPs, and dirty data between critical elements in supply and maintenance systems that capture CANN information. While this study addresses most of these topics generally, the potential exists for in-depth analysis of each. Working closely with the project sponsor's point of contact, we refined the project to the two objectives that would be the most beneficial to the sponsor and the Air Force.

## Assumptions

It is commonly believed that CANN events are underreported in the Core Automated Maintenance System (CAMS). Comparisons of manual CANN logs and CAMS data show that not every CANN event is recorded in CAMS. CANN man-hours are also underreported. CAMS requires the user to input only the start time of the uninstall action (T) and the time the reinstall action (U) is complete. The result is some man-hours associated with a CANN event (pre-inspections, towing, and operations checks) are not recorded with the CANN. Thus, the actual number of CANN events may be higher than recorded and man-hours expended for the CANN events are higher than actually recorded. However, the only automated collection source for CANN data is CAMS. We assume the fidelity of the data available in CAMS is sufficient for analysis and recommendations. The authors also acknowledge that a different system, CAMS for Mobility, or GO81, is used for maintenance data collection on Air Mobility Command (AMC)-owned and gained aircraft. In this study we did not look specifically at AMC aircraft; thus, we did not pull data from, perform analysis on, or make recommendations specifically for GO81.

## Limitations and Constraints

The first objective was to determine the feasibility of establishing Air Force CANN standards. In the project sponsor's request, we were asked to look at standards for CANNs resulting from both supply chain failure and maintenance convenience. At the present time, there is no widely accepted definition of a *maintenance convenience* CANN. Even with an established definition, there is no capability within CAMS to

record a cause for a CANN event. Thus, data is collected without distinguishing between supply chain failure and maintenance convenience CANNs. This report makes recommendations for CANN rates, regardless of cannibalization causal factors.

## Chapter 2

### Research and Analysis

#### Methodology

The preliminary analysis for this project began with a literature review from research sources such as Defense Technical Information Center (DTIC)-listed publications and other material from Air Force, MAJCOM, and field-level organizations on the subject of cannibalization. We also looked at Air Force and MAJCOM logistics metrics available in the Reliability and Equipment Management Information System (REMIS) and the Multi-Echelon Resources and Logistics Information Network (MERLIN) and residing on MAJCOM analysis web pages.

Once the study was formally initiated, we began gathering data specifically for the two objectives. Preliminary analysis indicated DoD and the Air Force have spent considerable effort analyzing different aspects of the cannibalization issue. We found that many analysis efforts addressed the supply chain failures that result in a CANN events. Therefore, for this study, we focused on the maintenance aspect, particularly the maintenance man-hour impact, of CANNs. For the first objective, we conducted interviews, gathered local policy and guidance, and collected local CAMS data from Kadena Air Base, Japan, and Elmendorf Air Force Base, Alaska. The interviews were conducted with logistics group commanders, deputy operations group commanders for maintenance, chief enlisted managers, squadron maintenance officers, production supervisors, maintenance analysis personnel, and maintenance supply liaisons in the operational squadrons. The CAMS data that was collected consisted of raw numbers of CANNs and CANN man-hours expended by work unit code (WUC) and by AFSC. We analyzed aggregate AF and MAJCOM logistics data available in REMIS. New query files had to be written for REMIS and run from the host site because of the magnitude of AF CANN and total maintenance man-hour data. Personnel statistics for PACAF and the Air Force were collected from base manpower spreadsheets and from the Air Force Personnel Center. Armed with this data, we reviewed the current method of computing CANN rates and developed a new metric to reflect the impact of CANNs on maintenance resources.

For the second objective, the automated and manual processes used to compute RSP CANN candidates were reviewed. We studied the CANN assumptions used in the Aircraft Sustainability Model (ASM). We identified methods used during MAJCOM RSP review cycle to negotiate levels for *nonfeasible* CANN items. We collected MICAP data from the Standard Base Supply System (SBSS) and CANN data from



CAMS for items listed on the PACAF F-15C/D units' quick reference lists<sup>8</sup> (QRL) and presented it as a CANN prototype assessment tool for the RSP review process. Since it is not currently possible to retrieve and collate the data from separate systems, we manually combined the data within Microsoft Access®, and then exported it to a Microsoft Excel® spreadsheet. A more detailed discussion on the prototype assessment tool development is presented in Appendix B.

## Research

**Recent CANN Studies.** The literature review revealed that cannibalizations have been the subject of much analysis in the recent past. In May 2001, the GAO testified to the House of Representatives Subcommittee on National Security, Veterans Affairs, and International Relations on early results from their ongoing audit of military aircraft cannibalizations.<sup>9</sup> The GAO-published report indicated that CANNs are prevalent in the Services and do have an effect on readiness and personnel retention. The report stopped short of quantifying the impact on readiness, but recommended the Services develop strategies to reduce the number of maintenance hours spent on CANNs, ensure that CANN aircraft do not remain grounded for long periods of time, and reduce the adverse effects of CANNs on maintenance costs and personnel.<sup>10</sup> Subsequently, the Office of the Secretary of Defense (OSD) commissioned a Logistics Management Institute (LMI) study to get a better understanding of the true cost of CANNs. While the study did recommend the Services focus on improving the availability of items that result in a high number of CANNs and provide overarching policy guidance on CANN efforts, it concluded that cannibalization, when properly managed and controlled, can be an efficient and cost-effective readiness enhancer. The study indicated that less than one percent of available maintenance man-hours DoD-wide are spent on CANNs and that CANN maintenance man-hour costs are less than one percent of the standard inventory price for additional spares. The LMI report did quantify the impact of cannibalizations on readiness, but from a positive aspect. Based on their evaluation of CANN and supply data from several DoD units, they concluded that CANNs enhanced mission capable (MC) rates by up to 56 percentage points and 17 percentage points on average, as opposed to a "no-CANN scenario." For the F-15C/D at Langley AFB, Virginia, the enhancement was 6 to 24 percentage points during a 6-month timeframe in 2001.<sup>11</sup>

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<sup>8</sup> Quick reference lists are developed locally by maintenance personnel and supply personnel. The QRL consolidates data normally found in separate data systems such as WUC, part number, stock number, and T.O. reference for frequently sourced supply items. The QRL facilitates the maintenance documentation of these items and the order of replacement parts through the supply system.

<sup>9</sup> U.S. House of Representatives, Committee on Government Reform, Subcommittee on National Security, Veterans Affairs, and International Relations, *Cannibalizations Adversely Affect Personnel and Maintenance*, May 22, 2001.

<sup>10</sup> United States General Accounting Office audit, GAO-02-86, *Services Need to Reduce Cannibalizations*, November 2001, pgs 27-28.

<sup>11</sup> Andrew Timko, Joseph Callender II, Regina Clifford, and Dennis Zimmerman, *DoD Cannibalization Assessment, Policies, Data, Causes and Effects*, Report LG102T1, Logistics Management Institute, July 2002.

Throughout the research process, two overarching and somewhat opposing themes became evident. CANNs cause a negative impact on readiness, morale, and personnel retention by placing an additional burden on maintenance personnel. Conversely, CANNs do have the effect of improving MC rates at a substantially lesser cost than buying expensive spare parts.

**Spares Funding.** In the Department of Defense's response to the GAO audit on CANNs, it was noted that the Air Force had initiatives in progress to resolve spares shortages in the field. Since the underlying reason for almost every CANN event is the lack of the right spare part at the time it is required, improving spares availability reduces the number of CANNs. What was not revealed, but has become more evident since the release of the audit, is that aggregate Air Force CANN rates are falling (see figure 2-1). It would be difficult to determine all the causal factors for this trend. However, it is likely that the increased Air Force funding for depot-level reparable (DLRs) and Defense Logistics Agency (DLA) funding for consumables is in part responsible. In the early 1990s, the strategy used to drive out inventory was to not fund the full requirement. Full funding was provided in only 4 of the past 7 years. In four of the seven underfunded years, less than 82% of the requirement was funded. This restricted the depots' ability to buy or repair needed spares. Under the lean logistics concept, the Air Force also reduced the number of spares in the pipeline. In 1994, the Air Force changed supply retention policy to reduce the time spares are retained prior to disposal from 13 to 8 years. These factors contributed to the steady decline of MC rates through the 1990's and an environment for sustained high CANNs. In FY99, as a result of Congressional and Air Force support to reverse this problem, full funding of known requirements and an additional \$382M in "bow wave" funds began to build back the spares pipeline. These funds began delivering in FY99 and continued through FY02. DLA has also earmarked \$500M over four years to increase support levels for aviation items. Fifty-three percent of this investment is targeted for AF weapon systems to increase item availability levels from 50% to 85% over the next two years.<sup>12</sup> Adjusted aircraft availability goals and AF wholesale-level logistics initiatives in progress should also positively impact spares availability and thus reduce the number of CANNs.

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<sup>12</sup> Statistics taken from "Air Force Working Capital Fund Briefing," Air Force Logistics Group Commanders Course, May 2002.

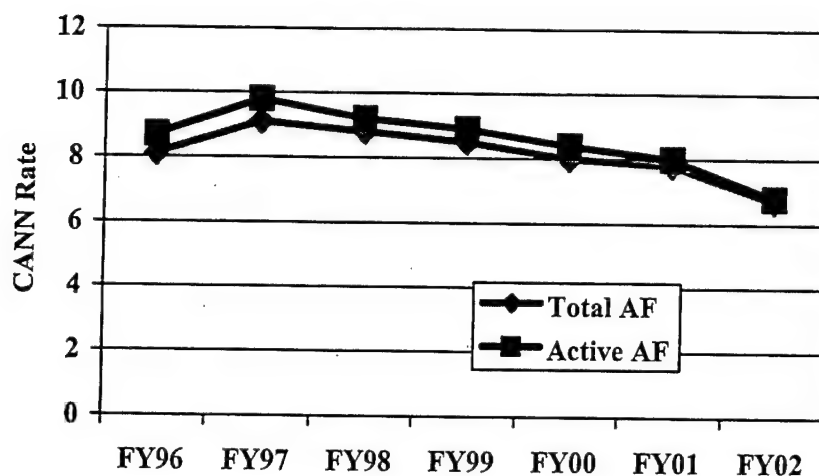


Figure 2-1. Air Force CANNs per 100 Sorties, All Aircraft  
Source: MERLIN

**Adjusted Aircraft Availability Goals.** Air Force Materiel Command (AFMC) uses the Aircraft Sustainability Model (ASM) as the computation engine for RSP item levels. ASM uses item data (demand rates, repair times, and procurement costs), along with operational factors (sorties and sortie durations) to build an RSP that achieves the Direct Support Objective (DSO) goals at the least possible cost. The DSO is the minimum number of aircraft needed to fly the War and Mobilization Plan, Volume 5 (WMP-5) scenario. For fighters there are dual DSOs to reflect surge and sustain tasking. It is expressed as a target number of aircraft or percentage of primary aircraft inventory (PAI) to the squadron. It is computed by using the following formula:

$$\text{DSO} = \frac{\text{Sortie Rate} \times \text{PAI}}{\text{Max Turn Rate}} + (\text{Spare Aircraft})$$

$$\text{Spare Aircraft} = \begin{array}{ll} 0, & 6 \text{ PAI} \\ 1, & 12 \text{ or } 18 \text{ PAI} \\ 2, & 24 \text{ PAI} \end{array}$$

ASM assumes that every item is capable of being cannibalized unless it has been flagged in the model as a hard-to-CANN item. Thus, many items can compute to zero and the RSP will still be able to meet the DSO goal because the model assumed that the item was available from a CANN aircraft. In 1999, LMI performed an analysis of the current RSP computation process at the request of MAJCOM commanders concerned about the high number of CANNs required to support deployed forces. Their analysis found the ASM computation process was valid, but DSOs were set too low to support partial squadron deployments that have become the norm. This is because the RSP computation is based on a typical squadron PAI of 24. When a partial package of 12 aircraft deploy, instead of the full 24, they deploy with an RSP that was computed assuming more spare aircraft than are actually available to the smaller package. The result is a higher percentage of

Codes (AFSCs) that contributed to the choice to leave the Air Force. Chief enlisted managers were quick to provide manning statistics that clearly showed where assignment and retention efforts should be focused. Maintenance technicians (journeymen or 5-skill level), who are performing a large portion of the CANNs, are the same skill-levels that are undermanned in the flightline units. Air Force-wide, the number of 5-level aircraft maintenance technicians declined drastically from the mid-1990s. In FY94, the Air Force had 97% of its 5-level authorizations filled; by FY00, this number was just 75%. According to REMIS data, in 2001 Air Force maintainers documented 531,780 man-hours on 79,318 CANNs, which equated to 6.7 man-hours per CANN event.<sup>17</sup> For the PACAF F-15C/D, the number was 7.2 man-hours per CANN. Although we cannot show a cause-and-effect relationship for skill-level manning versus CANN rates and CANN man-hours, it is intuitive that the fewer skilled maintainers there are, the more the increased workload associated with CANNs impacts available resources. In 2001, the Air Force Director of Maintenance (HQ USAF/ILM) initiated KEEP to provide commanders and supervisors of maintenance personnel with specific criteria and information aimed at improving the retention of experienced personnel. As a part of KEEP, ILM tasked the AFLMA to conduct a study on the cost and valuation of maintenance personnel. This study showed a direct relationship between the skill-level manning mix and productivity. The analysis revealed a theme common to all AFSCs evaluated—since FY94, the number of trainees increased while the number of trainers decreased. Using fighter electro-environmental systems as an example, the analysis also revealed a mathematical correlation between readiness, as expressed in not mission capable for maintenance (NMCM) rates, and maintenance experience. It showed that for on-aircraft maintenance, increases in the ratio of 3-level (trainee, <4 years of service) to 5- and 7-level (trainer, >12 years of service) electro-environmental systems technicians (electricians) were highly correlated with an increase in the NMCM rate (electro-environmental systems WUCs), or more simply put, a productivity drop.<sup>18</sup>

**CANN Rates.** As stated before, aggregate Air Force statistics indicate CANN rates are falling. However, some MDSs consistently show high CANN rates. This study examines Air Force and PACAF CANN statistics for one such MDS, the F-15C/D. As Figure 2-2 shows, the F-15C/D experiences CANNs at rates twice as high as the Air Force CANN rate average for all aircraft.

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<sup>17</sup> Statistics derived from REMIS program run by the REMIS office, specifically for this report. *CANN man-hours per CANN* is defined as the man-hours to uninstall and reinstall the donor part. It is calculated by taking the total number of CANN man-hours (hours associated with T & U CAMS actions) divided by total number of CANN events (T CAMS actions).

<sup>18</sup> Oliver, Steven A., *An Analysis of the Cost and Valuation of Air Force Aircraft Maintenance Personnel*, LM 200107900, Air Force Logistics Management Agency, July 2002.

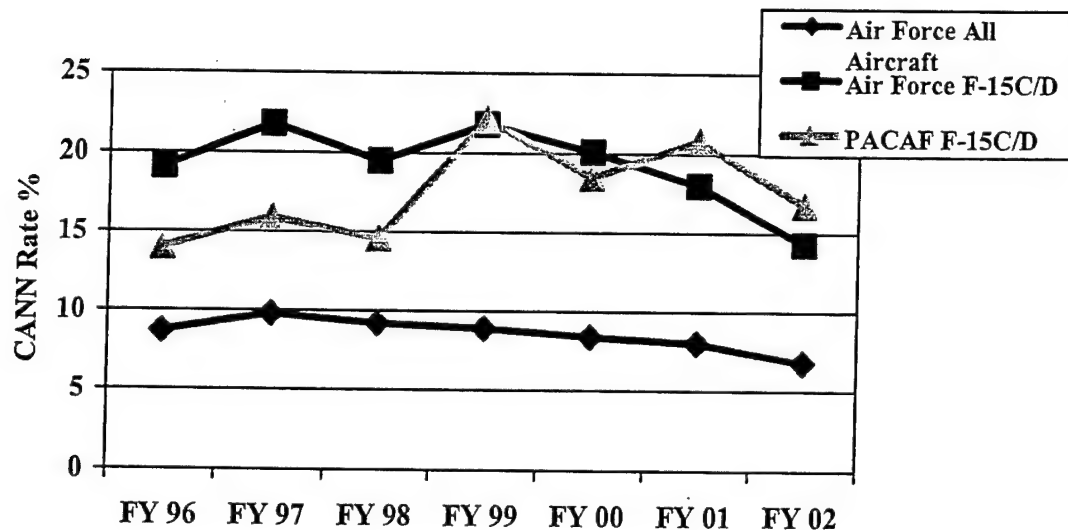


Figure 2-2, Comparison of CANN Rates, Source: MERLIN

Today, the Air Force calculates the CANN rate as the average number of CANNs per 100 sorties flown. From this point on, we call the metric *cannibalization rate for supply or CANN (S) rate*. The formula is:

$$\text{CANN (S) Rate} = \frac{(\text{Number of Aircraft-to-Aircraft CANNs}) + (\text{Number of Engine-to-Aircraft CANNs})}{\text{Total Sorties}} \times 100$$

This measurement should be evaluated in conjunction with the supply issue effectiveness rate. Since base supply relies on depots for replenishment, this indicator can be used in part, to indicate depot support.<sup>19</sup> However, for this study we wanted to look at the impact of CANNs on maintenance resources. For example, for F-15C/Ds, supply chain failures occurred twice as often as the AF fleet-wide average, but this rate did not reflect the maintenance impact. One way to reflect the maintenance impact is to measure how many CANN man-hours are expended as a percentage of total maintenance man-hours expended. Figure 2-3 compares the average CANN rate of all Air Forces MDSs to the F-15C/D rates for this CANN workload measurement. We call the metric *cannibalization rate for maintenance workload or CANN (M)*. The data is pulled from REMIS and is calculated as:

$$\text{CANN (M) Rate} = \frac{\text{CANN Man-hours Documented (CAMS T \& U Actions)}}{\text{Total Maintenance Man-hours Documented (All CAMS Actions)}}$$

<sup>19</sup> U.S. Air Force, *The Metrics Handbook for Maintenance Leaders*, December 20, 2001.

mission capable (MICAP) parts and CANNs against these aircraft.<sup>13</sup> In 1999, the Air Staff gained approval to adjust the fighter and airlift DSOs and fund the FY02 POM, with funds delivering FY02-FY04. The DSOs were increased for fighters from 68% (surge phase) and 63% (sustain phase) to 83% (surge phase) and 75% (sustain phase). As the availability goal (DSO) increases, ASM must increase the range and depth of RSP items. Interviews at PACAF bases highlighted the range and depth of the F-15C/D RSP as a causal factor for CANNs. PACAF monthly 7211 (logistics indicators) reports stated that predeployment CANNs to fill holes in their RSPs for split operations contingency taskings resulted in high CANN numbers for 2001. With increased DSOs, more spares should become available to the RSPs. This should reduce both the number of CANNs to fill predeployment RSP holes and the CANNs during deployments.

Aircraft availability targets (AAT) determine peacetime safety stock spares inventory levels for individual MDSs. They are set by using operational requirements to project a desired aircraft fleet availability. AATs adjust safety stock levels of peacetime operating stock (POS) to offset stock outages from demand spikes and unexpected repair times. AATs are reviewed every 2 years among Air Staff, MAJCOMs and AFMC. MAJCOMs provide peacetime sortie training requirements, and the Air Staff uses the Windows Integrated Logistics Assessment Model (WINLAM) to determine wartime sortie requirements. Historically, prior to release to AFMC, AATs were adjusted for cannibalization and lateral support potential. This meant the AATs input into the spares model were less than needed, based on the assumption that CANNs and lateral support would make up the difference. AFMC inputs targets following cannibalization adjustment into the Requirements Management System (D-200) spares computations. A recent Air Staff initiative increased aircraft availability targets in order to reduce the number of CANNs and lateral supply support actions. Starting FY02 and affecting the spares buy and delivery for FY03, the AF no longer adjusts the AAT based on the premise of available CANN or lateral supply support actions. Unadjusted targets better reflect the true operational requirement and models predict a 2.6% improvement in MC rate from this policy change alone.<sup>14</sup> Finally, based on an AFLMA study recommendation, the Air Staff approved a stockage policy change that allows the base to stock consumables after the first MICAP.<sup>15</sup> This change was implemented in FY02 and should alleviate CANN actions for some consumable parts.

**The Air Force Spares Campaign.** "The Air Force logistics community is undertaking a campaign to modernize and fundamentally reshape its entire spare parts process to better support expeditionary operations and put more spares in the hands of the maintainers."<sup>16</sup> This quote describes the charter of the Air Force Spares Campaign, led by Brigadier

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<sup>13</sup> "RSP Computation: Policy and Practice", Briefing given to Gen Patrick Gamble, PACAF/CC, by Dr. Randall King, LMI and Col John Günselman, USAF/ILSP, February 1, 2000.

<sup>14</sup> Daley, Dennis Lt Col, Bullet Background Paper on Aircraft Availability Targets, USAF/ILSY, October 2001.

<sup>15</sup> SMSgt Tony Nicholson, *Air Force Readiness Initiatives, Stockage Policy Changes*, Air Force Logistics Management Agency, LS 200004102, August 2000.

<sup>16</sup> SSgt A.J. Bosker, "Air Force Campaign Overhauls Spare Parts Process," Air Force Print News, January 16, 2002



General Robert Mansfield. The Spares Campaign seeks to improve Cold War-based spares processes. The Spares Campaign team, composed of 71 experts from the depots, Air Staff, and the MAJCOMs, boiled the numerous areas for improvement down to eight initiatives. The initiatives are paraphrased as follows:

- Change depot-level reparable (DLR) structure--set stable prices and allocate costs to responsible commands
- Improve spares budgeting--establish a single consolidated budgeting process for spares and consumable items
- Improve financial management--track execution of weapon system support against approved plan and budget
- Improve demand and repair workload forecasting--improved forecasts, enhanced supply and workload planning capabilities
- Establish virtual single inventory control point--centralized processes for consistent execution and enforcement of the spares buy and repair allocation
- Align supply chain management focus--identifies Supply Chain Manager as the quarterback to execute buy and repair priorities
- Standardize use and expand role of Regional Supply Squadrons (RSS) --make RSS standard for AF to support EAF operations
- Adopt improved purchasing and supply management--reduce purchase costs, improve product quality and delivery by implementing "Purchasing and Supply Management (PSM)" practices

These improvements should lead to better spares availability and thus fewer overall CANNs.

**Depot Maintenance Reengineering and Transformation (DMRT).** At the same time the Spares Campaign began, the AFMC/CC and AF/IL sponsored a similar effort for Air Force depots to address concerns that depot maintenance output was not keeping pace with current warfighter needs. Similar to the Spares Campaign strategy, DMRT used experienced personnel from MAJCOM, Air Staff, and HQ AFMC and the depots to identify issues and formulate a strategy to meet a depot maintenance desired end state of reduced flow times, increased production and throughput, and improved financial performance. To accomplish this, DMRT is focusing on the key areas of workload/production, financial processes and policies, Air Logistics Centers' organizational structure, depot infrastructure, workforce recruiting and training, materiel support to the depots, information technology strategy, and warfighter-focused metrics. DMRT began in July 2001 and the implementation is well underway. Further information can be found at <https://www.afmc-mil.wpafb.af.mil/HQ-AFMC/LG/dmrt/>. When realized, the gains in improved depot maintenance processes will ultimately mean more spares in the hands of field maintainers, and fewer required CANNs.

**Keep Enlisted Experience Program (KEEP).** While we found no data that quantified the extent to which high CANN rates affect retention, interviews with both senior maintenance supervisors and junior enlisted technicians in the field indicated that they are at least perceived as a factor. Maintenance personnel stated that it was the combination of high CANN rates and perceived low manning within specific Air Force Specialty

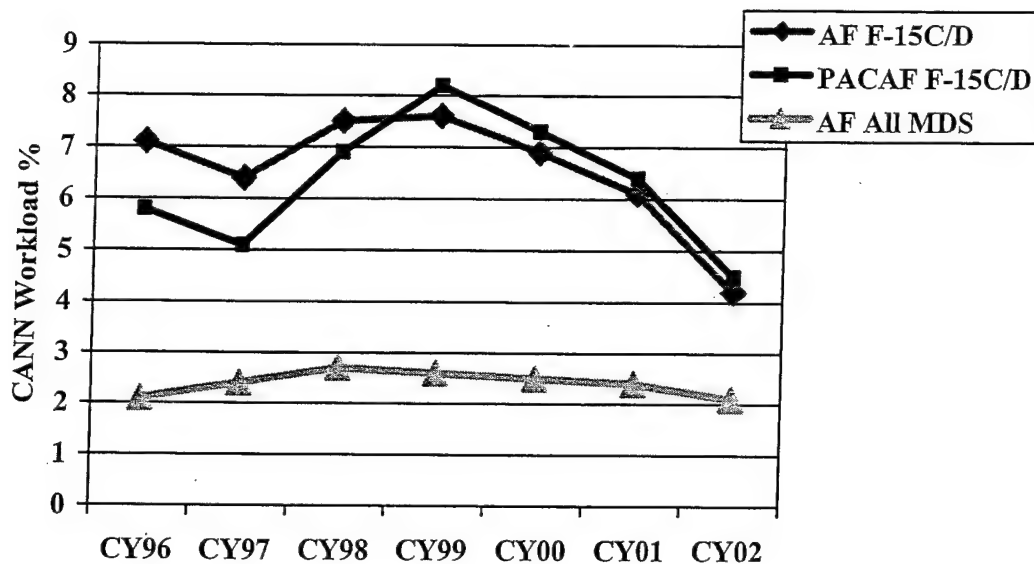


Figure 2-3. Percentage CANN Man-hours of Total Maintenance Man-hours  
Source: REMIS

This report does not assume that all maintenance man-hours expended are accounted for in CAMS. CAMS was not designed for man-hour accounting, and it has been reported that data collection in CAMS is burdensome for the user, with little perceived value.<sup>20</sup> Also, a significant percentage of hours that are not documented in CAMS are also not available for maintenance production. Indirect maintenance labor can include administrative support and documentation, meeting attendance, ceremonies, personnel management, performance feedback and evaluation, cleanup of work areas, maintenance on assigned vehicles, test equipment maintenance, and tool kit maintenance, to name just a few.<sup>21</sup> Even with these known drawbacks, CAMS is the source to record aircraft maintenance actions. As CAMS collects this data, it also collects the man-hours associated with them. Thus, we believe it is possible to at least gauge the CANN workload factor as a percentage of total maintenance man-hours recorded.

Research for this report focused on CANN data derived from on-aircraft or flightline maintenance. Air Staff and MAJCOM generally report CANN rates with the CANN (S) formula described above, again derived from on-aircraft maintenance. CANN rates for engines are not shown as logistics indicators. It is important to note, however, that engine-to-engine CANNs also occur. The research attempted to establish the workload associated with engine CANNs. Unfortunately, REMIS shows there is little reliable

<sup>20</sup> Air Force Inspection Agency Eagle Look Report, *Aircraft Maintenance Data and Collection and Use*, PN 01-507, 2001.

<sup>21</sup> A comprehensive discussion on the categorization of available maintenance man-hours can be found in the RAND report by Carl Dahlman, Robert Kerchner, and David Thaler, *Setting Requirements for Maintenance Manpower in the U.S. Air Force*, 2002.

CANN data available that can be segregated from the over-all maintenance man-hours expended in the engine shops. Data pulls on the power plant (23000 series WUC) return virtually no hours expended on CANN uninstall and reinstall (T and U) actions for off-aircraft maintenance in PACAF<sup>22</sup>. Engine-to-aircraft CANNs were reflected in the on-aircraft maintenance data. Thus, we were unable to apply the CANN (S) or CANN (M) metric for engine-to-engine CANNs.

The CANN (M) metric can also be viewed at base level. Data available in CAMS shows maintenance personnel at Kadena expended 6% of their total maintenance man-hours (recorded in CAMS) for CANNs from October 2000 until March 2002. While 6% may not seem like a significant figure, it equates to 17,633 maintenance man-hours or 6 maintainers working on CANNs every available duty hour for 18 months.<sup>23</sup>

To further drill into the metric, data collection was focused on the workload factors associated with CANNs to see where high CANN rates stressed maintenance resources the most. This revealed that a relatively small number of WUCs accounted for a large number of CANN man-hours expended. In the same 18 months at Kadena, the top 10 of 95 WUC sub-systems with CANNs reported against them accounted for 52% of the CANN man-hours (see Table 2-1). CAMS data was also retrieved at the 5-digit WUC level and cross-referenced to the particular part numbers that drove the CANN man-hours. Again, the top 10% of cannibalized part numbers produced over 50% of the CANN man-hours. The LMI study on CANNs showed similar results. For example, parts on the F-15 and F-16 aircraft that were cannibalized 6 or more times accounted for 59% of the total number of CANN actions.<sup>24</sup> These figures are important because they highlight that relatively few parts drive the CANN workload for maintenance.

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<sup>22</sup> Interviews with propulsion flight personnel from PACAF and ACC verified that CAMS CANN (T and U) actions are rarely used. Most in shop maintenance actions require the sequential removal of many parts to accomplish each task. These parts are then stored locally in facilitate other maintenance (FOM) bins. These actions are documented in CAMS as removal (P) actions for each individual part removed. When a part is required for a separate maintenance action on another engine, but cannot be issued from supply, it is removed from the FOM bins. The part is ordered from supply, but with the original documentation and a "mark for" change. In order to officially document this as a CANN, the technician would have to reinstall the parts sequentially in CAMS (Q action), in order to use a CAMS CANN removal (T) action on the required part. Due to parts unavailability, one part has the potential to move from a FOM bin multiple times. In short, the documentation required to convert a part to a CANN action in CAMS, that was already removed and documented as FOM, is extremely extensive with little perceived benefit. Thus, it is rarely done.

<sup>23</sup> Calculations made from man-hour availability factors listed in AFI 38-201, *Determining Manpower Requirements*, 20 March 2002.

<sup>24</sup> Op.cit., *DoD Cannibalization Assessment, Policies, Data, Causes and Effects*, LMI, p.4-9.

WUC	NOMENCLATURE	TOTAL
41A00	ENVIRONMENTAL CONTROL SYS	2405.1
74F00	RADAR SET	1256.0
76H00	CMS AN/ALQ 135(V)	985.3
76M00	ALQ-135(V) BAND 3	862.8
46A00	INTERNAL FUEL SYS	795.1
42A00	AC PWR GEN SYS	712.4
11A00	FORWARD FUSELAGE SECTION	578.9
76B00	AN/ALR-56C	502.8
52A00	AUTO FLIGHT CONTROL	476.2
46E00	FUEL CONTL IND WARN	472.1
	Top Ten Drivers (52%)	9046.7
	Total CANN Man-hours	17633

*Table 2-1. Kadena Top Ten F-15C/D WUCs for CANN Man-Hours, Source: CAMS*

Next, our research focused on the AFSCs most impacted by CANN activity. As mentioned above, CANNs were not distributed equally among WUCs, thus certain maintenance technicians shouldered more of the CANN workload. Figure 2-4 shows the distribution of F-15C/D CANN man-hours for Kadena and Elmendorf. For Kadena, the F-15 avionics systems maintainers (2A3X1 AFSC), who represented only 8% of the maintenance force, accounted for over 40% of all CANN man-hours recorded for on-equipment maintenance. At Elmendorf, the number for the same group was 43%. It is important to note that while the 2A3X1 maintainers carried a heavy CANN workload, they were also undermanned at the unit level. As a snapshot example, in April 2002 the 18 OG at Kadena was assigned only 41% of its authorized F-15 Avionics Systems maintainers. The 3 OG at Elmendorf had only 78% of their authorizations, but was projected to go even lower by the fall of 2002. Once senior maintenance leadership knows where CANNs are "hurting" production, actions can be taken to try and mitigate their impact. While the individual units reflected lower than optimal manning, AFPC statistics showed that PACAF was 91% manned overall (281 assigned to 308 authorized positions) for the 2A3X1 career field. Corrective actions may mean excluding certain AFSCs from non-AFSC specific duties (e.g. dorm manager and system administration), or it may involve working solutions through the personnel channels at MAJCOM and AF level. By also evaluating CANNs by their workload rate (CANN man-hours/Total maintenance man-hours), rather than just by their frequency (CANNs per 100 sorties flown) the Air Force can get a more accurate picture of the impact of CANNs on maintenance resources and focus improvements accordingly.

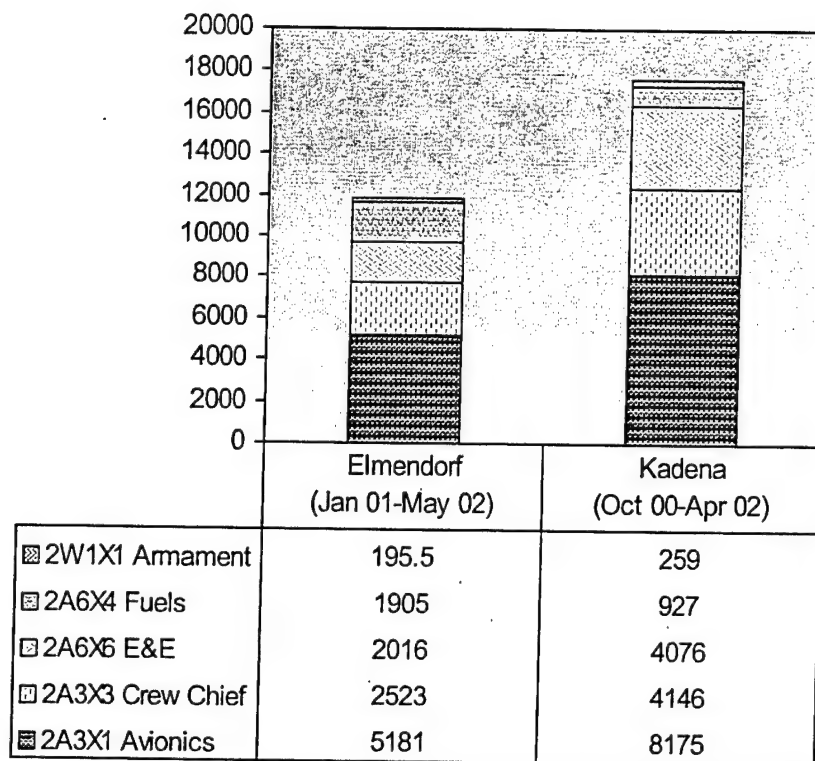


Figure 2-4. CANN Man-hours Expended by AFSC, Source: CAMS

**The RSP Review Process.** For the second objective, we studied the RSP review process as outlined in AFMAN 23-110, *USAF Supply Manual*, Volume 1, Part 1, Chapter 14, and in Volume 2, Part 2, Chapter 26. MAJCOM personnel involved in the process were interviewed. The process begins at base level where supply and maintenance personnel annually examine data pertaining to their RSPs. At this time, base-level personnel have the opportunity to influence which items (range of stock) are included in their RSP. They do not have the ability to change the item quantities (depth of stock) in the RSP. The depth is determined by the computations provided by the Aircraft Sustainability Model (ASM).

High-level RSP reviews are conducted annually at the air logistics centers, and are chaired by the system program office (SPO) RSP monitor. Typically, the MAJCOM RSP monitor (LGS) will invite maintenance personnel to participate in the review. The goal is to have every WUC system represented at the SPO review. This rarely happens because maintenance units must fund the TDY. Maintenance participation at the SPO review is helpful to resolve differences between MAJCOMs, and it almost always brings to light new demand information. At the review, the MAJCOM demand rates and other RSP-centric data are validated. Additionally, CANN flags (computer codes to signify whether

the item is a *feasible* or *nonfeasible* CANN candidate) and not-optimized (NOP)<sup>25</sup> quantities are also discussed because they have to be agreed upon and standardized across all MAJCOMS. Once the rates and other information are deemed accurate, the data is pushed to the ASM for computation. After the levels are computed, the MAJCOMs have one chance to challenge the RSP quantities. At this point, all quantity adjustments have to be justified and included in the SPO minutes for approval by HQ Air Force Materiel Command and Air Staff.

**CANN Flag Assignment.** The assignment of an item's CANN flag is determined by Air Force policy. Based on the following parameters an "N" flag is assigned when the item has a greater than 25% chance of breaking in removal or an 8-hour removal time for bombers, 4 hours for fighters, 2.5 hours for C-130s, 4.25 hours for C-5s, 2.25 hours for C-141s and C-17s. Also, canning the item cannot exceed the turn-time (from WMP-5) for reconnaissance and surveillance aircraft or break low observable technology for stealth aircraft.

If an item has an "N" (non-feasible) CANN flag, ASM will compute the RSP quantity as at least the truncated pipeline quantity. For example, if an item is expected to break 3.9 times in 30 days, ASM will put a minimum quantity of 3 in the kit. It may put a higher quantity in the kit based on backorder and aircraft availability probabilities. An item that has a "Y" (feasible) CANN flag may compute to an RSP level of 0. This happens when the demand level is so low that marginal analysis determines the cost savings of a zero balance is worth the minimal risk of the demand being higher than the number of spares available on the modeled CANN aircraft. These computations have resulted in squadrons cannibalizing heavily from their CANN birds prior to deployments to fill the RSP and during deployments to meet sortie requirements. Although the ASM computations can result in zero balances on critical items, it is not economically feasible to have an RSP computed with all items having an "N" CANN flag. Table 2-2 displays results from two ASM performance runs for an F-15C/D RSP. The first run is for an RSP with all items set with an "N" CANN flag. The second run is from an RSP that has been through the review process and has a "Y" CANN flag for all items except those that met the criteria for an "N" flag (> 4 hour CANN and > 25% chance of damage when removed or reinstalled). It is apparent that there is a huge cost increase with only a slight increase in aircraft availability at Day 1, and virtually no increase in aircraft availability by Day 30.

RSP Run	Cost	Availability Day 1	Availability Day 30
All "N" CANN Flags	\$37,921,426	92.96%	75.21%
Standard	\$19,326,130	85.46%	75.19%

Table 2-2. Comparison of F-15C/D RSP Computations with Differing CANN Flags,  
Source: ASM Performance Runs

<sup>25</sup> Quantities not-optimized by flying hour demand data; examples are tires and gun barrels.



More importantly, as mentioned in earlier discussion, the increase in DSOs for fighters from 68% (surge phase) and 63% (sustain phase) to 83% (surge phase) and 75% (sustain phase) will have a far greater effect on reducing CANNs associated with zero balance RSP authorizations. As the availability goal (DSO) increases, ASM must increase the range and depth of RSP items.

Although it is not feasible to assign an "N" CANN flag to each RSP item, it is possible to assign the flag in a more accurate manner. Currently, CANN flags are assigned based on the experience of subject matter experts. As part of the RSP review process, supply and maintenance personnel must review each item to see whether they meet the "Y" or "N" CANN flag criteria. It is very difficult to get an experienced maintenance technician familiar with each separate WUC listed on the RSP listing (D087) to the high-level RSP review. Even if each maintenance AFSC were represented, variances would arise due to the subjective nature of personal experience. Based on this observation, CAMS and SBSS data was collected for items found on the four PACAF F-15C/D squadrons' QRLs. The data was compiled into a prototype assessment tool to display relevant demand and CANN history.

WUC	NSN	PART NUMBER	NOMENCLATURE	MICAPS	CANN MHS	AVG CANN MHS	PRODUCT
41ACA	1660010631213	571545-7-1	COOLING TURBINE ECS	21	34	466	15844
41AEH	5330003768657	A0946	BACKUP VALVE GASKET		36	386.1	13899.6
52AC0	6615001377514	113D9320G3	RATE GYRO (RSA) SENSOR	44	48	277.7	13329.6
74JA0	6610010848224	4004771-907	VSD IND	68	49	247.9	12147.1
76MB0	5996013451134EW		RF AMP AFT AM- 7397	49	43	248.8	10698.4

*Figure 2-5. Excerpt from Prototype Assessment Tool*

**Prototype Assessment Tool.** The prototype assessment tool was developed for use by PACAF/LGS for their next F-15C/D RSP review process. The information it contains was derived from 12 months of CAMS and SBSS data. It is intended to provide an objective source of historical data to assist decision-makers in the assignment of CANN flags prior to the D087 being run through the ASM. It is not intended to replace maintenance personnel involvement in the RSP review process. For example, CAMS data exists that could lead to the automation or modeling of "N" CANN flag assignment based on the item's CANN frequency and average man-hours expended per CANN event. However, there is currently no data source for the "risk of damage > 25%" criteria. Therefore, the best possible process for assigning CANN candidate flags may be a combination of supply and maintenance subject matter expertise (to the extent available) and an automated tool to provide objective, historical data for reference.

There are other potential uses for the product. In a recently published RAND report on Air Force maintenance manpower, it was found that the model used to set maintenance manpower requirements, Logistics Composite Model (LCOM), is a highly data-intensive model that is not always fed high quality data. The RAND report suggested that one reason the Air Force may be underestimating maintenance manpower requirements is that LCOM does not model the most strenuous maintenance scenarios.<sup>26</sup> One such example may be CANN workload. The model places several parameters on the CANN workload factor, and adjustments to the model to add CANN fidelity must be made by the individual running the model. This person may or may not have readily available CANN data to assist in the model adjustments. The CANN prototype assessment tool could be used as a tool to aid more realistic manpower requirements modeling.

## Analysis

*"Metrics are nothing more than a barometer for pain. As leaders, our responsibility is to know where the pain is in order to alleviate it."*<sup>27</sup>

The initiatives described early in this chapter either have had or should have a positive impact on Air Force CANN rates. While overall statistics indicate a recent leveling off and improvement in CANN rates, it is imperative that the supply and maintenance community continue to focus their CANN reduction efforts on those weapon systems that suffer from a high CANN workload.

The increase in aircraft availability goals, AATs for peacetime operating stock and DSOs for RSPs, increased DLA funding of aviation parts, and stockage policy changes should have an immediate effect in execution years in reducing CANN events. Since the funds began delivery in FY99, supply backorders have been reduced from 615,529 in December 1998 down to 191,823 in April 2002. In the out-years, process improvements and policy changes realized from the Spares Campaign and DMRT should result in better spares acquisition and management, thus providing an environment for continued CANN reduction. And finally, AF/ILM is actively seeking solutions to improve the retention rates of 5- and 7-level maintenance technicians. Although we cannot prove that CANN reductions will occur as retention rates improve, it is intuitive that the impact of the maintenance workload from CANNs will be more equitably shared when the 5- and 7-level personnel requirements are more closely met.

Deciding how and where to set an Air Force standard for CANNs is feasible. In our research we found that data is available, although not currently readily accessible, that targets key areas for CANNs. To set Air Force standards, the right metrics must be

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<sup>26</sup> Carl Dahlman, Robert Kerchner, and David Thaler, *Setting Requirements for Maintenance Manpower in the U.S. Air Force*, RAND Project Air Force, 2002

<sup>27</sup> U.S. Air Force, *The Metrics Handbook for Maintenance Leaders*, December 20, 2001.

targeted. The formula the Air Force uses today to calculate a CANN rate is an indicator of how many supply chain failures have occurred for a particular weapon system; thus it is indicator of supply support to the warfighter. However, the current formula does not reflect the cost or *pain* of doing CANNs. To measure the *pain* or quantify the impact of CANNs on maintenance resources, the Air Force should look at CANN man-hours as percentage of total maintenance man-hours expended, the CANN workload rate or CANN (M). If it is determined that the Air Force should track CANNs against established standards, then the standards should be computed as an average from 36 months of CANN data. Currently Air Combat Command (ACC) uses this method to establish its CANN (S) standard. The same calculation method could be used for both CANN (S) and CANN (M) metrics. Once Air Force standards are established by weapon system, statistically significant deviations could be analyzed for both supply chain failure causal factors and maintenance impact. By adding the CANN (M) rate to the Air Force portfolio of logistics indicators, leadership at base, MAJCOM, and Air Force level would have a more holistic approach to evaluating CANN activity and possible subsequent courses of action.

This study was originally scoped to address only CANN activity for the F-15C/D MDS. However, at the request of the sponsor, research into engine-to-engine CANN activity was added. The research found no reliable CANN data from which to base analysis because current CANN documentation practices in the engine shops prevent segregation of expended CANN man-hours from all other maintenance man-hours expended. Without a data source for CANN man-hours, a quantitative analysis of CANN activity in engine maintenance is unattainable.

The CANN (M) rate is an actionable metric because there are important sub-elements within the data that can be analyzed and acted upon. One of these sub-elements is the data reflecting the WUCs that drive CANN man-hours. By identifying the 5-digit WUCs that are driving the CANN workload, corrective supply and maintenance actions can be taken. For example, a supply manager at base level could assess the stockage and issue effectiveness of the part numbered items associated with the 5-digit WUC, as well as assess the depot stockage and repair capacities. Maintenance managers could evaluate on-base repair capabilities for bottlenecks. At the MAJCOM level, this information could be useful to negotiate increased spares levels in POS and RSPs.

Another sub-element under the CANN workload rate is the data reflecting which maintainers are shouldering the CANN burden. By identifying the AFSCs stressed by CANN man-hours, maintenance leadership can target organizational and personnel corrective actions. A thorough evaluation of CANN dock programs was not within the scope of this study, but it provides an example for organizational considerations. The CANN Enhancement Program (CANN dock concept) was designed to help manage wing assets. It consolidates CANN aircraft from sister squadrons to ensure the wing has as few CANN aircraft as possible. These aircraft are managed, maintained and rebuilt by a single dedicated team. While in the CANN dock, refurbishment and preventive

maintenance are accomplished to the highest extent possible.<sup>28</sup> In interviews during the field visit to Elmendorf, production supervisors, the CANN dock chief, and the 3 OG/DOGM all indicated that their CANN Enhancement Program had proved to be an extremely beneficial organizational improvement. A repeated comment was that it provided a structured approach to CANN aircraft management, normalizing the workload across squadrons and improving CANN documentation. Elmendorf leadership believed the CANN dock program optimized the use of stressed maintenance resources. In addition to organizational considerations, the AFSC CANN workload rate can give maintenance group commanders decision-quality information to assist them in personnel policy issues. For example, this might mean excluding certain AFSCs from details and special duty assignments outside of their primary duties.

The analysis of the RSP review process revealed that there are mathematical models involved in the spares computation. The ASM provides the authorized RSP quantities of items (depth). MAJCOMs, with input provided by the bases, provide recommendations on which items (range of stock) their RSPs should include. The CANN candidate flags are assigned, indicating whether or not an item can feasibly be cannibalized, without an automated tool or model of any kind. The CANN flag assignment is based on the subject matter expertise of those maintainers consulted for the review. Research into CAMS and SBSS revealed that relevant CANN and MICAP data could be collected, ranked, and presented in an assessment tool to assist in the CANN flag assignment. With F-15C/D CAMS and SBSS data from Kadena and Elmendorf, a prototype assessment tool was built for PACAF/LGS to evaluate for Air Force-wide application during their next F-15C/D RSP review. It will be up to those charged with the RSP review to decide whether the CANN data available to them facilitated the process. An interesting finding from the PACAF F-15C/D CANN data was that 78% of the items cannibalized in FY02 took at least 4 hours to CANN.

Finally, this project relied heavily on CANN data available from CAMS.<sup>29</sup> This proved to be a laborious process because of the quality of data that is entered into CAMS. A full exploration of CAMS dirty data was originally requested, but it did not remain as an objective because of scoping concerns. It is important to note, however, that our research revealed clearly that CANN data collection has not been made "user-friendly" for maintenances technicians. The result is that the technician will many times take the easiest route out of the documentation process, which often means dirty data into CAMS. This makes it difficult for completely accurate analyses by base, MAJCOM, and Air Staff personnel since the systems they use (REMIS and MERLIN) are fed CAMS data.

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<sup>28</sup> 3 OG/ 3 LG Maintenance Operating Instruction 21-122, *Cannibalization Procedures, Aircraft Management, and Enhancement Program*, April 2002.

<sup>29</sup> This includes REMIS and MERLIN, which pull CAMS data for their reports.

## Chapter 3

# Conclusions and Recommendations

## Conclusions

Although there has been a marked decline in CANN rates recently, the overall number of cannibalization actions in the Air Force has grown substantially since 1996. Thus, CANNs have been the subject of much analysis and corrective actions have already been initiated. Most importantly, adjusted requirements modeling and funding for these requirements has begun to show positive results in lower TNMCS rates and CANN reductions. Unfortunately, we cannot eliminate CANN events and there will still be MDSs that experience a high rate of CANNs. A more holistic approach needs to exist for maintenance and supply chain managers to identify and reflect the impact of high CANN rates for each MDS and to facilitate corrective actions. The holistic view should include both CANN (S) and CANN (M) metrics to reflect AF CANN data. The CANN workload metric could be broken down further to show for which systems CANNs have the most impact on maintenance resources, which parts drive the most CANN man-hours, and which maintainers are hit the hardest. These metrics should give senior leaders decision-quality information to evaluate possible courses of action. Additionally, if Air Force standards are developed, further research into CANN policy and organization would be beneficial (e.g. CANN docks and hangar queen management).

1. The CANN rate used today, CANN (S) measures the number of CANNs per 100 sorties. It is an indicator of supply chain performance, not the maintenance impact associated with the CANNs.
2. A CANN workload metric, CANN (M), reflects the impact of CANNs to maintenance resources. The CANN workload rate is calculated as the number of CANN man-hours as a percentage of total maintenance man-hours documented in CAMS. It can be broken down further to reflect WUCs and AFSCs with high CANN man-hours.
  - a. A relatively few number of items (from 5-digit WUC level) result in a high percentage of CANN man-hours. Supply corrective actions should be focused on these items.
  - b. Certain AFSCs experience higher number of man-hours spent on CANNs than others. Maintenance leadership can manage organizational and personnel resources with CANN workload rates in mind.
  - c. While qualitative data indicates that there is engine-to-engine CANN activity, accurate engine-to-engine CANN data from maintenance data systems is not available for analysis.

3. Needed improvement in the collection of maintenance data has long been recognized. Improvements are needed in CAMS (or identified for Integrated Maintenance Data System [IMDS]) to facilitate the maintainer's process for inputting CANN data. An initiative to educate the maintenance community on the value of quality documentation should help all maintenance data collection, particularly CANN data collection.
4. The current RSP review process is not devoid of a mathematical model. Each item on an RSP has been run through the ASM model, which evaluates operational requirements, demand history, and item cost to determine authorized stock levels. The process by which MAJCOMs must determine CANN candidates for the RSP, however, relies heavily on subjective input. The methodology for determining RSP CANN candidates could be enhanced by using an automated assessment tool containing historical CANN and MICAP data for the weapon system. The information contained in this tool could also be useful for personnel charged with manipulating the data fed to LCOM to reflect CANN activity for a particular weapon system. Additionally, it may be necessary for the Air Force to review its criteria for assigning CANN candidate flags for items on the RSPs. Based on the PACAF F-15C/D CANN data retrieved from CAMS, 78% of all items cannibalized in FY02 resulted in at least 4 maintenance man-hours expended. This finding suggests that the criteria for assigning CANN candidate flags needs to be reviewed to ensure the Air Force assigns these flags to the items with the highest impact on CANN workload.

### **Recommendations**

1. USAF/ILM develop policy for reporting CANN rates with two metrics, CANN (S) CANN (M). MAJCOM/ LGs could supplement this policy, if required.
  - a. The CANN (M) rate, by MDS, be added as a metric for Air Staff-, MAJCOM-, and base level reporting of CANNs. The formula for its computation should be sent to all Analysis agencies.
  - b. The CANN (M) rate and the formula for its computation be added to the *U.S. Air Force Maintenance Metrics Handbook* at next publishing
  - c. The CANN (M) rate be added into the Mission Performance cannibalization module of the Multi-Echelon Resources and Logistics Information Network (MERLIN) program to provide common access to this indicator.

**OPR: USAF/ILM**

**OCR: AFLMA (Item B)**

2. AF/ILM and MAJCOMs work together to determine the advisability of establishing AF standards for CANN rates. If the AF adopts CANN standards,

then both CANN (S) and CANN (M) rates, by MDS, should be considered and the standards established by an integrated process team consisting of AF/ILM, MAJCOM/LGM, and AFLMA/LGM personnel.

**OPR: AF/ILM**

**OCR: MAJCOM/LGs, AFLMA**

3. CAMS (or the follow-on system) be modified for easier, more accurate collection and reporting of CANN data.
  - a. The three-screen process for entering CANN activity into CAMS should be streamlined.
  - b. Recommend CAMS be modified so a CANN history report can be run that captures WUC, national stock numbers (NSN), and nomenclature associated with each CANN event. REMIS should capture this data in order to roll up MAJCOM CANN histories by 5-digit WUC and NSN. The prototype assessment tool submitted with this report and validated by PACAF/LGS should be used as a template.

**OPR: USAF/ILM/ILG**

**OCR: SSG**

4. Once CANN history reports by WUC and NSN are available, recommend Air Force establish policy to incorporate them into the RSP review process. MAJCOMs should run reports prior to RSP reviews for their use in objectively assigning CANN candidate flags to RSP items.

**OPR: AF/ILM**

**OCR: MAJCOM/LGs, AFLMA**

5. Air Force review current criteria for assignment of CANN candidate flags. CANN flags should be assigned to the items with the highest CANN workload impact, thus those items that are cannibalized often and require an extensive amount of time to CANN. These are the items that rank highest in the prototype assessment tool.

**OPR: USAF/ILG**

**OCR:**



## Appendix A

### Glossary

ACC	Air Combat Command
AFLMA	Air Force Logistics Management Agency
AFSC	Air Force Specialty Code
ASM	Aircraft Sustainability Model
BLR	Base Level Review
CAMS	Core Automated Maintenance System
CANN	Cannibalization
DMRT	Depot Maintenance Reengineering and Transformation
DoD	Department of Defense
DSO	Direct Support Objective
DTIC	Defense Technical Information Center
GAO	General Accounting Office
IMDS	Integrated Maintenance Data System
KEEP	Keep Enlisted Experience Program
LCOM	Logistics Composite Model
LMI	Logistics Management Institute
MC	Mission Capable
MERLIN	Multi-Echelon Resources and Logistics Information Network
MICAP	Mission Capable (aircraft-grounding part)
NOP	Not Optimized (supply quantity not flying hour demand based)
PAA	Primary Aircraft Authorized
PACAF	Pacific Air Forces
POS	Peacetime Operating Stock
QRL	Quick Reference List
RBL	Readiness-Based Leveling
REMIS	Reliability & Equipment Maintenance Information System



RSP                      Readiness Spares Package

SBSS                     Standard Base Supply System

WINLAM                 Windows Integrated Logistics Assessment Model  
WUC                      Work Unit Code

## Appendix B

### Prototype Assessment Tool

In order to present relevant CANN data to facilitate the assignment of CANN candidate flags, the prototype assessment tool was developed using PACAF F-15 C/D data from CAMS and SBSS for the period 1 Sep 01 through 31 Aug 02. At the present time, no system can pull data from all the fields in both CAMS and SBSS that are required to populate this product. Therefore, the data was collected from the two systems and manually combined. The list of items was collated from the all PACAF F-15C/D squadron QRLs. Since the QRLs associated 5-digit WUCs to the items' national stock number (NSN), we ran the list of NSNs (Column B) through the Supply Data Bank at the AFLMA for SBSS data on the number of MICAPS (Column E) for each item listed in the previous year. A CANN history report (Screen 104) was run against these items (by 5-digit WUC, Column A) in CAMS for Kadena and Elmendorf, PACAF's F-15C/D bases. The CANN history report produced the number of times a CANN event occurred for a particular WUC (Column F) and the cumulative CANN man-hours expended for that WUC (column G). A formula to calculate the average CANN man-hours per CANN event for each WUC was embedded in the product and presented in Column H. The intended use of the tool is to provide the RSP review process with relevant CANN data. To determine which items are the most "costly" in terms of maintenance man-hours, we embedded a formula to multiply the frequency of CANNs (Column F), times the total CANN man-hours (Column G). The product of this calculation is listed in Column I. By sorting the data in Column I in descending order, a "ranked" list of most "costly" CANNs is presented. The combined information can give supply and maintenance personnel involved in the RSP review process the RSP items' historical CANN man-hour and MICAP data to assist in the CANN candidate flag assignment.

The prototype assessment tool forwarded with this report contains two worksheets. The first contains WUCs and NSNs that had CANN data and could be uniquely assigned to each other. The second worksheet contains 5-digit WUCs that had CANN data, but either did not have an NSN (may have been incorrectly entered in CAMS) or that had more than one NSN. Since we were not able to determine which NSN to assign the CANN data, we separated these items into different worksheets. A MICAP history was included for all NSNs associated with the WUCs listed as a point of reference.



"PAF F15C RSP  
Assessment Tool.xls"

For example, given the data used in this study, we would recommend screening all the potential CANN candidates using the metric of CANN incidents, times CANN man-hours. The mathematical product of this data captures, with a single number, the WUCs that are costly in terms of maintenance man-hours. These WUCs are cannibalized often

and take a long time to CANN. For the 1 Sep 01 through 31 Aug 02 data listed in the RSP assessment tool, the data can be sorted into categories as shown below. Again, the product of multiplying Column F, times Column G results in Column I. Their product then ranks the WUCs and associated NSNs.

Product (Column I)	Frequency	Percentage of WUCs
0 - 100	590	0.746
101 - 1k	117	0.148
1k - 5k	58	0.073
5k - 10k	10	0.013
10k - 20k	9	0.011
More	7	0.008

Table B-1. *CANN Man-hours x CANN Occurrences*  
*Source: CAMS PACAF F-15 C/D Data*

From the ranked data in the RSP assessment tool, we would recommend looking at the WUCs whose CANN frequency, times cumulative CANN man-hours product is greater than 1000 (1K). This means looking at a total of 84 RSP CANN candidates instead of all 791 items with CANN data, or only 10% of the total candidates. If concerned that screening out 90% of the records is too severe for an initial cut, using products greater than 100 will add only an additional 117 potential candidates and now includes 25% of the total candidates. The graph below shows the distribution of WUC workloads.

## Appendix C

### Distribution

HQ USAF/IL  
HQ USAF/ILG  
HQ USAF/ILM  
HQ USAF/ILP  
HQ AFMC/LG  
HQ ACC/LG  
HQ AMC/LG  
HQ AMC/DDO  
HQ AFRC/LG  
HQ USAFE/LG  
HQ PACAF/LG/LGM/LGS  
HQ AETC/LG  
HQ AFSOC/LG  
HQ AFSPC/LG  
ANG/LG  
3 MXG/CC  
18 MXG/CC